



Climbing the Extravehicular Activity (EVA) Wall – Safely

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A circular image showing an astronaut in a white spacesuit floating in space, tethered to a white structure. The Earth's surface with clouds is visible in the background.

Our Goal

To show how involving safety organizations during the design life cycle can enhance the ultimate success of a project or program.



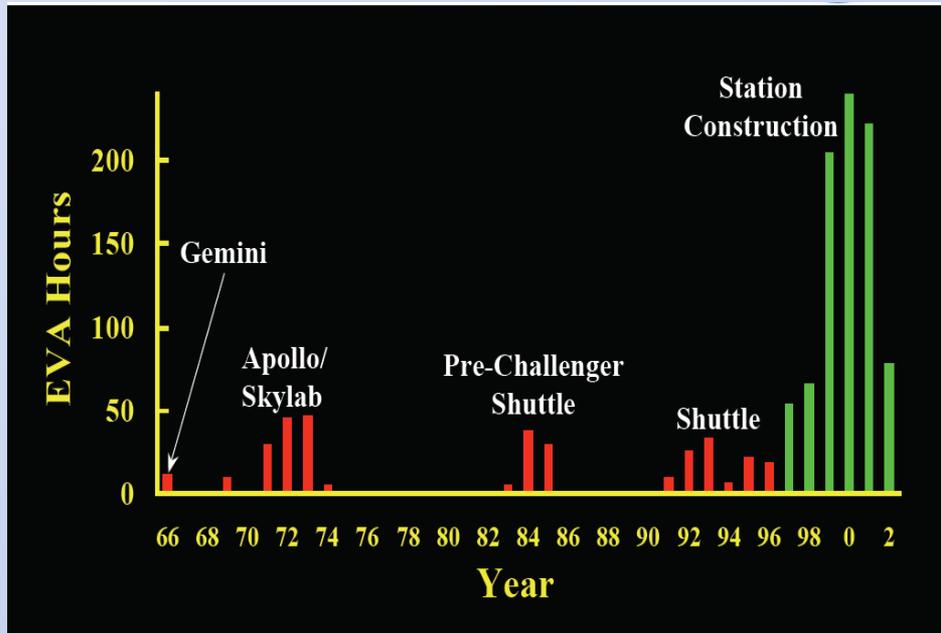
How are we going to accomplish this?

- Explain the initial EVA Challenge for the build up of the International Space Station (ISS)
- Describe Safety's participation in the early design and testing of EVA hardware for ISS
- Describe Safety's role in ensuring the success of EVAs for the ISS program
- Results of Safety involvement
 - Examples of how safety inclusion in a project team can contribute to the success of the program

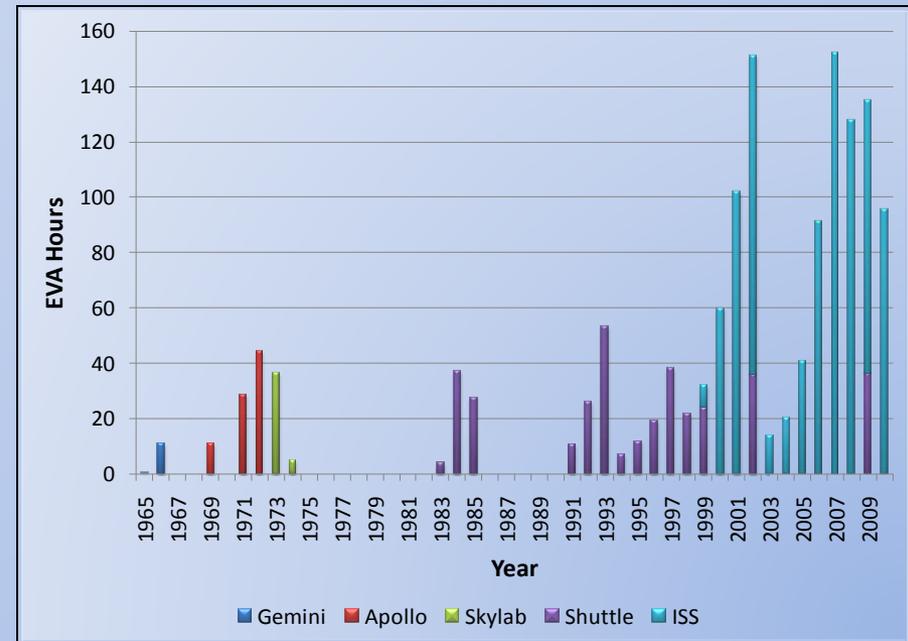
The EVA Challenge

- The massive number of EVA hours that was anticipated to fully assemble the ISS became known as the “*wall of EVAs.*”
- The relatively large number of spacewalks associated with this “wall of EVAs” was considered to be quite a challenge.

Predicted



Actual



A circular frame showing an astronaut in a white spacesuit floating in space. The astronaut is positioned in the upper left quadrant, with their body angled towards the viewer. The background is a vast view of Earth from space, showing the blue atmosphere, white clouds, and brownish-green landmasses. The text "EVA SAFETY - THE EARLY DAYS" is overlaid in the center of the image in a bold, black, sans-serif font.

EVA SAFETY - THE EARLY DAYS



EVA Testing for Space Station

- Shuttle Detailed Test Objectives (DTO's)
 - STS-49 - Assembly of Station by EVA Methods (ASEM)
 - STS-54, 57, 51 - DTO 1210
 - STS-63 – DTO 671, EVA Development Flight Test-1 (EDFT-1)
 - STS-69 – DTO 671, 672, 833, EDFT-2
 - STS-72 – DTO 671, 672, 833, EDFT-3
 - STS-76 – DTO 671, EDFT-4
 - STS-86 – DTO 671, EDFT-5
 - STS-87 – DTO 761, EDFT-6
- These EVA's demonstrated everything from proof of concept for truss build, to demonstration of new tools that were being developed for ISS.
- EVA Safety developed operational safety assessments, certified all EVA hardware, assessed hardware through all design phases, and provided real-time support during each EVA.





EVA Safety in the Beginning of ISS Program

- Participated in the development of safety requirements for the EMU and EVA tools for use on ISS
- Participated in early hardware concept development
- Participated in Preliminary Design Reviews (PDRs) through Critical Design Reviews (CDRs) to review hardware designs for incorporation of safety requirements
- Participated in NBL hardware testing, procedure development
- Certified all ISS EVA hardware

A circular frame showing an astronaut in a white space suit floating in space. The astronaut is positioned in the upper left quadrant, with their body angled towards the viewer. The background is a vast view of Earth from space, showing the blue atmosphere and white clouds over a dark landmass. The text "EVA SAFETY'S ROLL IN THE ISS PROGRAM" is centered in the middle of the image in a bold, black, sans-serif font.

EVA SAFETY'S ROLL IN THE ISS PROGRAM



Safety's Roll in ISS EVA

- EVA Safety supports ISS Program through the EVA Project Office by ensuring all EVA planning, hardware development and assembly, sustaining engineering, and real-time operations are accomplished safely with the highest rate of mission assurance.
- EVA Safety interacts with and maintains the complete life cycle for EVA tools, Extravehicular Mobility Unit (EMU) hardware, and operational procedures.

SSP/ISS EVA Support Flow

Program support

PDR, CDR, PSRP, SRP, JOP, CRs

- *Assess all data packages and Hazard Reports for sound engineering analysis and completeness*

EVA hardware support

EMU/EVA Tools Panel, FESRRP, GCARs

- *Assess hardware requirements and designs for EVA safety documentation compliance*

Operations support

NBL training, VR lab, flight rules, procedures, verification, risk identification, ORAESR

- *Generate an operational risk assessment executive summaries for EVA procedures*

Flight Readiness

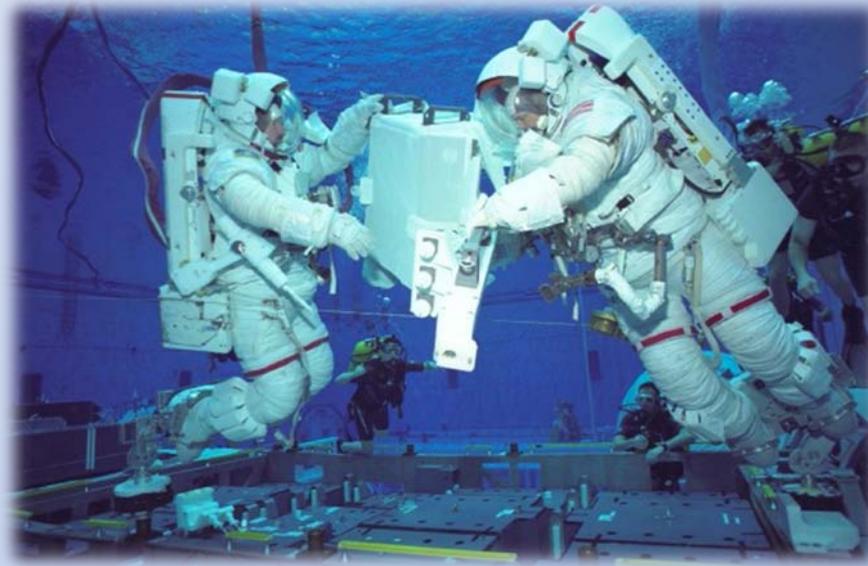
EVA:
CoFR1/2

S&MA:
CD FRR
SMSR

Real-time operations

MER Console
Real-time
safety
Tiger
Teams/Team
4

Neutral Buoyancy Lab (NBL) EVA runs and other crew training events are assessed for safety of hardware operations



Hardware training events



Virtual Reality (VR) Lab

A circular frame showing an astronaut in a white spacesuit floating in space, tethered to a white structure. The Earth's surface is visible in the background, showing blue oceans and white clouds. The text "RESULTS OF SAFETY INVOLVEMENT" is overlaid in the center in bold black letters.

RESULTS OF SAFETY INVOLVEMENT



**Involving safety early in the design
analysis assures compliance with
safety requirements**



Examples of Safety Early Involvement

- During review of the stress analysis for the Simplified Aid For EVA Rescue (SAFER) tower latch, EVA Safety identified latch piece parts missing from the analysis. Additionally, the incorrect factor of safety was used in the analysis. Inclusion of the parts and correct factors of safety resulted in the successful certification of the redesigned latch mechanism.
- Identified necessary updates to EMU ground turn-around procedures which resulted in expedited ground processing of the EMU for flight.
- Provided EVA Safety expertise to the International Partner's through their hardware design and safety process.



The involvement of safety provides for successful anomaly resolution. This can also lead to success with any future use of the hardware.



Latch Failure

- Anomaly: SAFER latch inadvertently released on STS-121.
- Action: Developed a temporary solution to prevent the inadvertent release in the near term. Then collaborated with engineering to develop a permanent solution.





EMU Sensor Failure

- Anomaly: EMU Carbon Dioxide Sensor failed during EVA preparation
- Action: As a member of the Tiger Team, EVA safety participated in the investigation and real-time decision meetings to reach an agreement on continuation of the EVA. Flight Rules were reviewed and approved by EVA Safety, engineering groups and medical branch to cover all situations with failure of CO2 sensor.



Potential ISS Contamination

- Issue: Potential ISS atmosphere contamination from byproducts produced by regeneration of the Metal Oxide (METOX) containers within the ISS
- Action: During the review of the test plan and final reports, EVA Safety requested that additional chemical compounds be added to the list of those being analyzed. After these additions, the test plan and final report were approved, allowing continued use of METOX regeneration on ISS.





An R&R Assessment

- Hazard: The Remove & Replace (R&R) of the failed Bearing Motor Roll Ring Module (BMRRM) on ISS US EVA-14, required a powered connector demate in order to keep power to ISS during the change out.
- Action: EVA safety assisted with the development of an electrical inhibit protocol that would allow the canister to be safely removed and not cause interruption of power to the ISS.





**A fully integrated safety team is
better equipped to support the
project during real-time
operations**



Stuck Solar Arrays

Anomaly: During STS-97, the solar arrays (SA's) became stuck on deployment. Prior to this mission there was no plan for EVA to interface with this hardware, and it was identified as a keep out zone.



Action: As a member of the Tiger Team, EVA Safety worked with the hardware developers, operations engineers and astronauts to develop a plan for safely avoiding the sharp edges and other hazards on the blanket box. This allowed for a successful SA deployment and established a plan for use on future SA deployments.



Solar Array Repair

Anomaly: During deployment of the solar array on STS-120, the solar array snagged on itself and tore part of the array.



Action: EVA Safety played a direct role in identifying tools and influencing procedures to keep EVA crewmembers safe and avoid further damage to ISS. Safety controls were defined and implemented that protected the crew from possible electrical shock and minimized risk to sharp edges from the damaged array.



Missed Inhibit

Hazard: During STS-124, prior to EVA 2 the required electrical inhibits had not been implemented as required for the EVA installation of cameras.

Action: EVA Safety personnel, on console in the Mission Evaluation Room (MER), brought this issue to the attention of the MER manager. It was then elevated to the flight director who assured that the inhibits were put in place to mitigate the shock hazard to the crew.





**Safety involvement provides the
opportunity for special
assessments and innovations for
understanding and addressing risk**



EMU Contamination Assessment

Anomaly: The on-orbit EMU cooling system became contaminated requiring the EMU fleet to be taken out of service for approximately a year.

Action: EVA Safety actively participated in the Tiger Team investigation to determine the contamination source and corrective actions. EVA Safety then provided FMEA/CIL and Hazard Report controls that were used in the final approval of EMU's for return to service.



EMU Cut Glove Assessment

Anomaly: EMU gloves experienced cuts and abrasions during EVAs

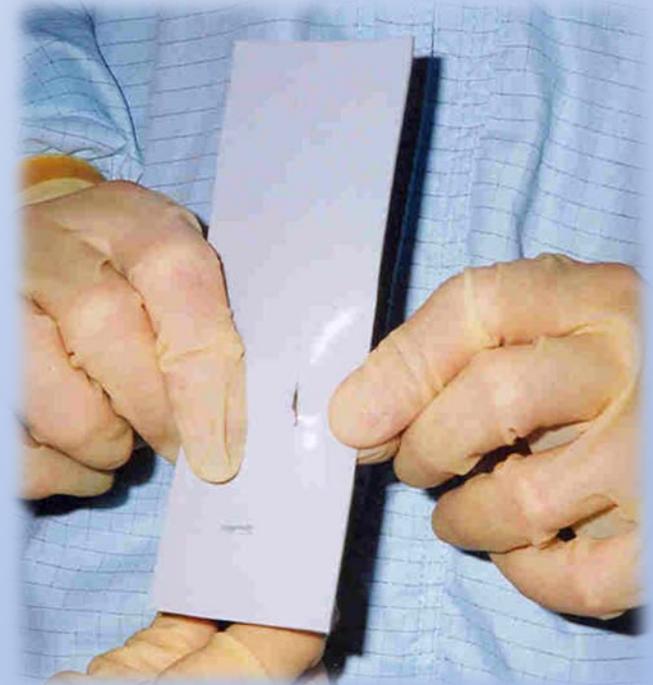
Action: EVA Safety assisted in the development of go/no go criteria and its application in real-time assessments of EVA glove damage, resulting in EVA abort/continuation decisions.





Innovations

- Instituted a Sharp edge inspection program
 - Traveled to hardware provider sites to provide training.
 - Effected change out of nuts on PM and Node hardware during inspection
- Coordinated the development of a EMU glove Touch temperature memo
 - Provided the ISS hardware developers with more details on the EMU glove thermal capabilities than was published in their requirements. It allowed for a more flexibility in the design of the operational procedures
- Operational Risk Assessment Executive Summary Report (ORAESR) development
 - This report was instituted to document all operational hazards and their controls associated with each Shuttle mission.
 - Was reformatted for ISS to document hazards associated with each element.



The Future

- **Participation has begun in the Constellation program**
 - **Writing/assessing safety requirements**
 - **Participated in design selection assessments**
 - **Affected design of the Lunar Rover**
 - **Suit to Orion umbilical and connector design**
 - **Authored preliminary Hazard Reports for the initial Cx suit design**
 - **Authored EVA SR&QA Plan**



In Summary

- The success of the EVA team, that includes the EVA project office, Crew Office, Mission Operations, Engineering and Safety, is assured by the full integration of all necessary disciplines.
- Safety participation in all activities from hardware development concepts, certification and crew training, provides for a strong partnership within the team.
- Early involvement of Safety on the EVA team has mitigated risk and produced a high degree of mission success.

